budget was spent on the Network Operations Center (NOC), which monitors traffic flow and troubleshoots problems.[58] Given the predominance of fixed costs in an Internet backbone, it made sense to recover these costs from users through fixed connection fees.[59] After all, in this fixed-cost environment, if a network is not saturated, the incremental cost of sending additional packets is essentially zero. However, because the Internet is becoming increasingly congested (*see* Section V below), interconnection prices should be based on the long-run incremental cost (LRIC) of interconnection which takes into account the costs of adding additional transmission capacity as traffic increases.

Also significant in the development and use of fixed connection fees was the difficulty in measuring usage in packet-switched networks. As discussed in Section III above, a one-minute phone call in a circuit-switched network requires only one accounting entry in a usage data base; but in a packet network, that one-minute call would require ultimately 2,500 entries because every packet is independent.[60]

B. The CIX Exception

The statement has been made that "[c]ommercial Internet service providers . . . accept traffic from the other without settlements payments or interconnection charges."[61] The person making this general statement did not qualify his

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[58] *See* Jeffrey K. MacKie-Mason & Hal R. Varian, Some Economics of the Internet, at 6 (Feb. 17, 1994).

[59] It has been reported that the transport costs of regional networks is considerably less, percentagewise, than were the transport costs of the NSFNET. *See* Padmanabhan Srinagesh, "Internet Cost Structures and Interconnection Agreements," Gerald W. Brock, editor, Toward a Competitive Telecommunication Industry: Selected Papers from the 1994 Telecommunications Policy Research Conference, 251, 256-57 (1995)("IP transport accounts for 25% to 40% of a typical [regional] ISPs total costs.").

[60] *See* page 18 and n.38.

[61] *See* page 1 *supra, quoting* Gerald W. Brock, The Economics of Interconnection, at i-ii (April 1995).

statement; however, this person clearly was referring only to a small subset of the commercial Internet: the Commercial Internet Exchange (CIX).[62]

The assertion that CIX members exchange traffic at the CIX router "without settlements charges" is correct. However, the statement is misleading to the extent it suggests that CIX members exchange traffic for free, as documented below. Moreover, the statement is grossly misleading to the extent it suggests that the CIX model is followed ubiquitously throughout the Internet. As discussed above, whether with regard to connections at other (non-CIX) hubs or between local and regional networks (or regional and backbone networks), "nearly all users faced the same pricing structure for Internet usage: . . . [an asymmetrical] fixed bandwidth connection . . . [known as] 'connection pricing.'"[63]

As noted in Section II.C above, at the beginning of this decade, additional national backbone networks were constructed (or leased) to transport commercial Internet traffic. These new networks no longer needed to purchase transport or routing from ANS. However, the new networks did have a need to interconnect so their customers could reach the customers of other networks. As most of these networks were already connected to ANS, an interconnection agreement with ANS would have met their customers' needs. However, ANS demanded that the new backbones pay it an asymmetrical connection fee for interconnection.[64] Although ANS's charges were designed to recover its non-

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[62] *See* ibid. ("The CIX members therefore agreed to exchange traffic on a 'sender keep all' basis in which each provider charges its own customers for originating traffic and agrees to terminate traffic for other providers without charge.").

[63] Jeffrey K. MacKie-Mason & Hal R. Varian, Economic FAQs About the Internet, at 8 (Aug. 21, 1994). *See also* Graham Finnie, "Internet Expansion: The Price of Success," Communications-Week at 37 (Oct. 10, 1994)("Most Internet providers do not charge users by traffic volume, or the number of packets sent, but for a contracted, leased bandwidth, generally the capacity of the access circuit to the provider's point of presence.").

[64] Under the ANS commercial-use contract, regional carriers were asked to agree to accept commercial traffic from ANS for free. But, if the regional network wanted to send traffic back across ANS, a charge would be levied on the provider. *See* Ellen Messmer, "NSF, ANS Charged with Internet Abuse," Network World, p. 6 (Dec. 23, 1991).

NSFNET-related costs, ISPs, unaccustomed to paying for access,[65] balked at ANS CO+RE's proposal. Indeed, it was this proposal that led three of the then-largest commercial ISPs — CERFNet, PSI, and Uunet — to form CIX.[66]

The CIX was formed on two basic principles: the exchange of traffic would be both "AUP free" and "settlements free." The three founding CIX members agreed to exchange traffic without charging the other — essentially a "sender keeps all" or "bill and keep" arrangement.

However, several facets of the CIX policy confirm that interconnection at the CIX router was not free. First, the "settlements free" policy applied only to CIX members and, then, only to traffic of their own, direct customers. Paragraph 9 of the CIX Membership Agreement provides in pertinent part:

> A Member shall not in a discriminatory manner (as between other Members) or without reasonable justification decline to offer CIX interconnectivity to its direct customers. Provided, however, that notwithstanding any of the foregoing, any Member shall be able to offer virtual private networks, to administer traffic and/or access restrictions for particular networks where requested or if required to provide special services, . . . to enter into separate interconnectivity agreements with other Members . . . .[67]

In addition, paragraph 10 of the Membership Agreement clarifies that any member is free to enter into "any separate contract or agreement with any other Member or third party on any terms."

These CIX policies allow members to resell Internet services to other carriers only if those carriers join CIX. This means, for example, that NEARNet

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[65] It bears repeating that NSFNET did not charge regional networks a connection fee so long as they agreed to adhere to its acceptable use policy.

[66] Also in response, some regional networks reclassified themselves as AUP-compliant research and education customers to avoid ANS's new connection fees. *See* Ellen Messmer, "Users Question New NSFNET Usage Policy," Network World, p. 19 (March 30, 1992).

[67] The CIX further expressly reserved the right to modify its "settlements free" policy. *See* CIX Association Membership Information.

must be a CIX member to pass traffic through the CIX, even though NEARNet is already connecting to CIX through AlterNet. The fact that AlterNet is a CIX member does not give its network-provider customers the right to access CIX.

Second, consistent with the past practice of the NSFNET, each member must pay the cost of the facilities necessary to connect their network with the CIX router. Paragraphs 6 and 7 of the CIX Membership Agreement provide respectively that each "Member will provide a circuit, at its own expense, from a location of its choice to a CIX router" and that each "Member will provide circuit termination and packet switching equipment at its end of the circuit, at its own expense . . . ."

Finally, CIX charged what at the time was a relatively hefty annual membership fee ($10,000). Thus, although CIX declared connectivity with no settlements, it essentially made its membership fee the price of no settlements.

CIX essentially held a monopoly over hub services until the NAPs and MAEs were deployed. Membership in CIX grew steadily — to 24 members by the end of 1993, including some international and foreign networks.[68] About this same time, there was a sudden growth of new Internet service providers, most of whom had not joined CIX but whose customers' traffic was traversing the CIX router. In the late summer of 1994, CIX announced that it would begin "filtering" (*i.e.*, blocking) this reseller traffic:

> After careful consideration of membership . . . , the CIX Board has reaffirmed its decision to filter-out the routes of non-members. The guiding principle of this decision is that of fairness to the members who are paying for the service of route advertisement. Consequently, non-CIX member routes will be filtered at the CIX router beginning November 15, 1994. Pending members whose applications are in process as of November 15 will not be filtered, and they will have through the end of 1994 to complete payment.

[68] Not all CIX members connect directly to the CIX router. Some members (*e.g.*, regional networks) connect *via* other CIX members (*e.g.*, a backbone).

As one CIX member explained at the time, Internet users "have two choices: They can tell their service providers to play the game and pay their share, or go to service providers who are already CIX members."[69]

The decision by the CIX board was highly controversial.[70] Smaller providers, who had been using the CIX router for free, questioned why they should pay the same annual membership fee (then $7,500) paid by much larger providers — because, with no sliding scale, small providers would essentially be subsidizing larger providers. Nevertheless, CIX's announcement was highly effective; its membership mushroomed from 40 in August 1994 to 104 by mid-November 1994 and to 155 by January 1995.[71]

The CIX compensation model, the first developed for the commercial Internet, has not been followed elsewhere and likely will not survive. As Bob Collett, the president of CIX (and founder of SprintLink) stated recently:

> [T]he telephone system has relied on a system of settlements for years. Sure, Internet folks are used to getting things for free, but that's just not going to last.[72]

Vinton Cerf, the president of the Internet Society (and an MCI senior vice president) made the same point recently, stating: "My own personal belief is that

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[69] Karen Rodriguez, "CIX to Restrict Internet Access," InfoWorld, p. 1 (Aug. 1, 1994), *quoting* Bill Yundt, executive director of BarrNet, a CIX member.

[70] As one reporter noted, "The CIX IP resale ban can endure while it has a virtual monopoly on multiprovider connectivity, but there could be competition for the CIX in the near future," referencing the new NSF-sponsored NAPs. Ellen Messmer, "IP Service Providers Face Traffic Shutdown," Network World, p. 5 (Aug. 22, 1994).

[71] *See* Ellen Messmer, "It's Showdown Time on the Net," Network World, p. 9 (Nov. 14, 1994); Ellen Messmer, "CIX Emerges as Trade Group for 'Net Providers,'" Network World, p. 23 (Feb. 6, 1995).

[72] Steve G. Steinberg, "Toll Roads May Be the Future Route of the Internet," Los Angeles Times, Business, Part D, page 2 (Jan. 25, 1996).

there is more than a zero sum game going on, and revenue has to be distributed in such a way that everyone's costs are recovered":[73]

> Well this [CIX settlements free policy] is an interesting business model, but, as far as I can tell, it doesn't last very long. * * * Plainly the Internet is not something that will survive unless all of its costs are paid for.[74]

Within the last year or so, as additional network access points have opened, the CIX has attempted to redefine itself from a hub provider to a trade association of public data communications internetworking services industry.[75] As one industry observer has noted, "the CIX router [has] become essentially meaningless with the opening of the NAPs and MAE-West and the expansion of MAE-East."[76]

V. The Future of Internet Pricing

The economists most familiar with the Internet have stated: "Privatization and commercialization of the Internet means that providers of network connectivity and services will have to confront issues of pricing and cost recovery. When connectivity was provided to users via government subsidies, little attention was paid to these issues. Suddenly, they have become quite significant."[77]

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[73] Christine Hudgins-Bonafield, "How Will the Internet Grow," CMP Publications, Inc.

[74] "Vint Cerf to COOK Report: Discussion Needed of Benefits Derived from Backbone Resources: Fair Compensation to Backbone Providers Must Be Ensured," The COOK Report on the Internet, at 5 and 7 (Sept. 1995).

[75] *See, e.g.*, SprintLink Customer Handbook, at ¶ 6.7 (Version 2.1, Oct. 11, 1995)("It should be noted that the routing services at the CIX router are becoming less important over time, while its trade association characteristics are becoming increasingly important.").

[76] Gordon Cook, "CIX Reorganization," COOK Report Summary (May 1995). *See also* Gordon Cook, "Erratic Actions Symptomatic of a Struggling CIX," COOK Report Summary (Dec. 1994)("The CIX router as the central point for exchange of commercial traffic in the Internet [is] dead.").

[77] Jeffrey K. MacKie-Mason and Hal R. Varian, Pricing Congestible Network Resources, at 1 (Nov. 17, 1994).

Indeed, these economists have stated that "the major" challenge facing the Internet over the next two years "will be to find ways to support interconnection":

> The technical problems are relatively straightforward; it's the accounting and economic problems that are tricky. We think it inevitable that a system of settlements will emerge.[78]

As these observers have explained, Internet "resource usage is not always symmetric, and it appears that the opportunities to free-ride on capacity investments by other network providers are increasing."[79]

The problem the Internet faces is an usual one: "[it] was not just successful, it was too successful."[80] As stated by Vinton Cerf, interconnection compensation issues are also becoming important given the growth in the Internet:

> When there wasn't too much in the way of resources involved to make it work, having one outfit pay for the whole thing was OK, and everyone could pay the same amount. For it didn't matter too much that you used less than your friend even though you both were paying the same amount. In short, the difference between amounts paid didn't matter that much, because the absolute amount wasn't large enough to matter.
>
> It turns out that as the system gets bigger, it demands more resources and, justifying the expenditure for these resources is harder because you are competing with other applications for the use of those resources. As the business side of the Internet becomes more and

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[78] Jeffrey K. MacKie-Mason, Economic FAQs About the Internet, "What problems will the Internet face in the next 2 years?" (July 11, 1995).

[79] Ibid. "For example, suppose a new net provider hosts a number of World Wide Web sites near a NAP, and then purchases a very short connection to the NAP. Web traffic flows are very asymmetric: a handful of bytes come in from users making requests, and megabytes are sent back out in response. Thus, for the low cost of leasing a short-distance connection to a NAP, a provider could place a huge load onto other networks to distribute to their users, while this provider does not have to deliver much incoming traffic." Id.

[80] *See, e.g.,* Padmanabhan Srinagesh, "Internet Cost Structures and Interconnection Agreements," Gerald W. Brock, editor, Toward a Competitive Telecommunication Industry: Selected Papers from the 1994 Telecommunications Policy Research Conference, 251, 263 (1995).

more visible, it is more and more critical to justify making the investment of resources.[81]

The flat-rated connection fee structure used in the Internet is suffering from the classic problem of the commons:

> Unless the congestion externality is priced, there will inevitably be inefficient use of the common resource. So long as users face a zero price for access, they will continue to "overgraze."[82]

As one speaker stated at a recent Internet conference, "If the perceived cost of an activity is zero, it encourages unnecessary consumption."[83] And as The Economist noted only last month:

> The net's explosive growth (its traffic is doubling every nine months) has resulted in traffic jams. * * * The Internet has strange economics — individual users are charged for signing on, but can then surf the net for nothing. Until a way is devised to bill them for the traffic they generate, there is little incentive to increase capacity to cope with expensive bottlenecks that are not costing particular site operators money.[84]

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[81] "Vint Cerf to COOK Report: Discussion Needed of Benefits Derived from Backbone Resources: Fair Compensation to Backbone Providers Must Be Ensured," The COOK Report on the Internet, at 7 (Sept. 1995).

[82] *See* Jeffrey K. MacKie-Mason and Hal R. Varian, Pricing Congestible Network Resources, at 1 (Nov. 17, 1994). *See also* G. Hardin, "The Tragedy of the Commons," Science, xx, 1243-47 (1968).

The problem of the commons originated in colonial New England where all of a town's residents had the right to graze their cattle, free of charge, in the town square. Because they were not charged for the grass their cattle ate, the residents' incentive was for their cows to consume as much of the grass as possible before others did the same. This unrestricted consumption ended up destroying the commons. The commons were thus a quasi-public good, nonexcludable (anyone can let their cows graze there), but rivalrous (if one cow eats a blade of grass, another one cannot also eat the same blade).

The Internet is analogous to the commons. Because end users typically pay a flat, non-usage ~~based fee for the traffic they generate~~, their incentive is to "overgraze," using the network so heavily that it becomes congested.

[83] Graham Finnie, "Internet Expansion: The Price of Success," CommunicationsWeek, at 37 (Oct. 10, 1994).

[84] "The Interminablenet: Why is the Internet so slow? And what can be done about it?", The Economist at 70 (Feb. 3, 1996).

Nearly every Internet user has encountered congestion (*e.g.*, the inability to reach a desired Web site). This congestion is caused largely by the fact that nearly all usage of the Internet backbones "is unpriced at the margin."[85] It is because local and regional networks pay a fixed fee for unlimited access up to the maximum throughput of their particular connection that the problem of the commons arises. The externality exists because a packet-switched network is a shared-media technology: each extra packet that Sue User sends imposes a cost on all other users because the resources Sue is using are not available to them. This cost can come in the form of delay or lost (dropped) packets.

It is important to point out that when the Internet becomes congested, access is being rationed by queuing instead of the more economically efficient method of rationing by pricing. Economists have noted that "[m]aking people wait is one way to ration a scarce commodity or service, but it is a woefully inefficient procedure":

> A critical factor to understand about queues is that no one derives any benefit from the waiting costs that are borne by those who stand in line. In a freely functioning private market long lines are understood and accepted as a signal that prices should be raised.[86]

Congestion has yet not become a major problem on the Internet, although it has occurred in the past.[87] Although SprintLink has experienced phenomenal growth in traffic,[88] one of its engineers stated that the Internet "traffic volumes were so small it just looked like a rounding error."[89] Nevertheless, "[p]roviders

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[85] *See* Jeffrey K. MacKie-Mason & Hal R. Varian, Economic FAQs About the Internet, at 8 (Aug. 21, 1994).

[86] E. Stokey & R. Zeckhauser, A Primer for Policy Analysis (1978).

[87] Several examples of Internet congestion are discussed in Jeffrey K. MacKie-Mason, Economic FAQs About the Internet, "How can the Internet deal with increasing congestion?" (July 11, 1995).

[88] Between January and August 1994, SprintLink reported an increase of Internet traffic from five terabytes per month to 30 terabytes per month. *See* Ellen Messmer and Joanie Wexler, "Network Overload Hobbles SprintLink," Network World, p. 6 (Sept. 5, 1994).

[89] Steve G. Steinberg, "Toll Roads May Be the Future Route of the Internet," Los Angeles Times, Business, Part D, page 2 (Jan. 25, 1996). One observer noted that, as of mid-1993, none of the

Continued on Next Page

that are offering unlimited access at a very low fixed price are soon going to be in trouble. Either they change their pricing structures or quality goes through the floor. There has to be some relation between level of use and charging."[90]

Without an incentive to economize on usage, congestion can become quite serious. Indeed, the problem is more serious for data networks than for many other congestible resources because of the tremendously wide range of usage rates. On a highway, for example, at a given moment a single user is more or less limited to putting either one or zero cars on the road. In a data network, however, a single user at a modern workstation can send a few bytes of e-mail or put a load of hundreds of Mbps on the network. As one student of the Internet observed:

> Today, any undergraduate with a new Macintosh is able to plug in a digital video camera and transmit live videos to another campus or home to mom, demanding as much as 1 Mbps. Since the maximum throughput on current backbones is only 45 Mbps, it is clear that even a few users with relatively inexpensive equipment could bring the network to its knees.[91]

Congestion would not likely become a problem for many years, if ever, if Internet usage were limited to ASCII e-mail. However, the demand for multimedia services is growing, and the difference between plain ASCII and multimedia is dramatic. Ordinary ASCII text uses about 44 bits per word. Telephone-quality voice uses 21,000 bits per word, and stereo CD uses 466,000 bits per

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national backbones was large enough to qualify for AT&T's largest discounts. *See, e.g.,* Padmanabhan Srinagesh, "Internet Cost Structures and Interconnection Agreements," Gerald W. Brock, editor, Toward a Competitive Telecommunication Industry: Selected Papers from the 1994 Telecommunications Policy Research Conference, 251, 258 (1995).

[90] Graham Finnie, "Internet Expansion: The Price of Success," CommunicationsWeek, at 37 (Oct. 10, 1994), *quoting* Glenn Kowack, managing director of Europe's largest commercial Internet provider, EUnet.

[91] *See* Jeffrey K. MacKie-Mason, Economic FAQs About the Internet, "How can the Internet deal with increasing congestion?" (July 11, 1995). *See also* Tom Steinert-Threlkeld, "Fee Issues Arise as Traffic Increases on Superhighway," The Dallas Morning News, Business, Cybertalk, p. 1K (Aug. 6, 1994).

word. Network quality video without compression is about 100 *megabits* per second; with compression, it's about 45 Mbps — the entire capacity of the old NSFNET.[92]

The growth of the World Wide Web is perhaps the most serious immediate concern.[93] Now growing faster than any other part of the Internet, the Web allows Internet users to access text, pictures, sound, and even video at the click of a button. This new Internet interface has the potential to create serious traffic congestion. A million bytes, for instance, captures the entire text of War and Peace, but only five spoken words, five medium-sized pictures, or three seconds of video. If a sufficient number of people simultaneously attempt to download video files, a serious traffic jam could result; for example, in 1994, a deluge of requests for images of the Shoemaker-Levy comet smacking into Jupiter disrupted usual Internet traffic.[94]

Capacity and the resultant congestion will explode once the Internet is also used for interactive video and voice, given the much greater bandwidth required for these applications (compared to e-mail or even Web pages).[95] Not only are these new applications bandwidth intensive, but they are also delay in-

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[92] *See* Jeffrey K. MacKie-Mason & Hal R. Varian, Some FAQs About Usage-Based Pricing, at 3 (Sept. 1994).

[93] Introduced in 1992, the Web had 130 Web sites in 1993, 11,576 in December of 1994, and 38,796 in June of 1995. Internet '95 at 47. The World Wide Web was developed at the CERN lab in Switzerland in 1989 to facilitate the sharing of information among researchers in high-energy particle physics. It extended the concept of "hypertext" not only with a document and between documents, but also between different computer sites accessible to each other *via* the Internet.

Several years later, in 1993, a small group at the University of Illinois developed a graphical interface to the World Wide Web they called Mosaic. This Mosaic Web browser and Mosaic-like browsers (*e.g.*, Netscape) were the first applications that fueled the current public interest in the Internet.

[94] Joshua Quittner, "A Crash of Comet and Computer; Influx of Onlookers Slows Down Internet," Newsday at A6 (July 20, 1994).

[95] Vinton Cerf, the president of the Internet Society and an MCI senior vice president, candidly admitted, "We are worried about interactive video and voice requirements." *See* Christine Hudgins-Bonafield, "How Will the Internet Grow," CMP Publications, Inc.

tolerant. As one respected Internet observer has stated, "If congestion remains unpriced it is likely that there will be increasingly damaging episodes when the demand for bandwidth exceeds the supply in the foreseeable future."[96]

This impending congestion problem has led to numerous proposals to fundamentally re-evaluate the pricing of the Internet.[97] One possibility is to prioritize packets, putting a label in the header so that routers give priority to those who demand it (*e.g.,* video, voice). This would entail significant monitoring and billing costs, as the routers would have to measure the prioritized traffic and bill the originating party. A more plausible method would be to sell "priority chits" up front and have the routers prioritize the packets with the most chits.[98]

Another possibility to address congestion is to move to usage-based pricing, charging users for volume of packets sent. This approach also would involve substantial monitoring costs — and would necessitate measuring the usage of every end user. Moreover, it might price voice and video out of the Internet entirely, because each consumes many times the bandwidth of pure text.

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[96] *See* Jeffrey K. MacKie-Mason, Economic FAQs About the Internet, "How can the Internet deal with increasing congestion?" (July 11, 1995).

[97] Technical solutions are also being pursued. For example, some networks now use a "Web cache," a computer with a large hard-disk, that keeps a copy of every page from the Web visited by the area's users the previous day or so — thereby avoiding the need to transport queries to and responses from the original Web site. However, caching is not the answer to all the congestion problems. It is not well suited to data such as videos, nor to the one-off pages generated by database searches. And companies with Web sites often object because caching robs them of valuable information about their viewers — the sort that advertisers demand. *See* "The Interminablenet: Why is the Internet so slow? And what can be done about it?", The Economist at 70 (Feb. 3, 1996).

[98] Vinton Cerf, the president of the Internet Society, is convinced that, for the Internet to survive, it will "need to have different classes of service in order to meet these [new time-sensitive, data-intensive] requirements and distinguish the costs of the services so that the people who need them, and use them, can bear those costs rather than trying to make it a completely flat arrangement." "Vint Cerf to COOK Report: Discussion Needed of Benefits Derived from Backbone Resources: Fair Compensation to Backbone Providers Must Be Ensured," The COOK Report on the Internet, at 5 (Sept. 1995).

Usage-based pricing nevertheless has been adopted at several universities and throughout New Zealand and Chile, *albeit* at the cost of decreased usage.[99]

Jeffrey MacKie-Mason, an economist intimately familiar with the Internet, has recommended a particularly innovative proposal, which he calls, a "smart market." Although he favors retaining the fixed connection fees, he proposes supplementing those fees with usage-based congestion prices:

> The basic idea is simple. Much of the time the network is uncongested, and the price for usage should be zero. When the network is congested, packets are queued and delayed. The current queuing scheme is FIFO. We propose instead that packets should be prioritized based on the value that the user puts on getting the packet through quickly. To do this, each user assigns her packets a bid measuring her willingness-to-pay for immediate serving. At congested routers, packets are prioritized based on bids. In order to make the scheme incentive-compatible, users are not charged the price they bid, but rather are charged the bid of the lowest priority packet that is admitted to the network.[100]

This proposal has a number of nice features. In particular, not only do those with the highest cost of delay get served first, but the prices also send the right signals for capacity expansion in a competitive market for network services.

> One important feature of congestion prices is that they not only discourage usage when congestion is present, but they also generate revenue for capacity expansion. Indeed, it has long been recognized that under certain conditions the optimal congestion prices for a fixed amount of capacity will automatically generate the appropriate amount of revenue to finance capacity expansion.[101]

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[99] Christopher Anderson, "The Internet," The Economist Survey at 12 (July 1, 1995).

[100] *See* Jeffrey K. MacKie-Mason, Economic FAQs About the Internet, "How might prices be used to control congestion?" (July 11, 1995). *See also* Jeffrey K. MacKie-Mason & Hal R. Varian, Some FAQs About Usage-Based Pricing, at 1 (Sept. 1994).

[101] Jeffrey K. MacKie-Mason & Hal. R. Varian, Pricing Congestible Network Resources, at 2 (Nov. 17, 1994).

If all of the congestion revenues are re-invested in new capacity, then capacity will be expanded to the point where its marginal value is equal to its marginal cost.

VI. Summary

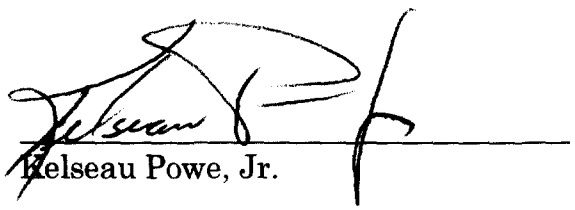
Internet providers and networks do not exchange traffic for free. Smaller networks must obtain (and pay for) their own connection facility. In addition, they must pay the larger carrier a connection fee (based on the size of their connecting pipe), and sometimes a usage fee as well. Everyone charges for the transport (or transit) of another's traffic.

The Internet operates in a fully competitive environment — free from all regulation and regulatory obligations. To this extent, the Internet experience suggests that, if freed of regulatory responsibilities, the telecommunications industry would also adopt asymmetrical interconnection agreements between carriers of different sizes — with money flowing from smaller carriers to larger carriers. Such arrangements reflect the elementary economic fact that smaller carriers receive more value by connecting to large carriers than *vice versa*.

As discussed in Section II above, care must be exercised in drawing additional analogies between the Internet and the PSTN, given the major differences in technology and regulatory obligations. However, the congestion problems the Internet is beginning to experience with fixed connection fees may suggest that the solution for both networks is use of a combination of fixed-capacity charges and usage-based charges.

CERTIFICATE OF SERVICE

I, Kelseau Powe, Jr., do hereby certify that on this 4th day of March, 1996, I have caused a copy of the foregoing **U S WEST COMMENTS** to be served via hand-delivery upon the persons listed on the attached service list.



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